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# *PINUS*

## (pines)

Pines (*Pinus*), the most important conifers, grow around the world in the Northern Hemisphere. Southward they occur as far as Nicaragua, northern Africa, Asia Minor, and Malaya. One species crosses the Equator in Sumatra. Thirty-six of the 90 to 100 species in the world are native in the United States.

Pine trees usually have furrowed bark, resinous wood, and an upright axis which produces each year a long shoot with one or more circles (whorls) of spreading branches. Buds are large, pointed, usually resinous. The needlelike leaves are borne in clusters or bundles of mostly 2 to 5 (rarely more or only 1). They persist from 2 to 12 years in different species.

Numerous male strobili are clustered at the base of current year's growth in lower part of crown. Ovulate strobili are borne on the same tree, especially in upper part of crown, sometimes clustered near the end of the current year's growth. The woody cones may be egg-shaped or cylindrical but are sometimes oblique and not symmetrical. They mature at the end of the second year (rarely third) and may shed promptly or remain attached to the tree, sometimes not opening. Seeds are long-winged or sometimes wingless. Cotyledons 4 to 15.

Pines are separated into two groups. The soft or white pines (subgenus *Haploxylon*), have mostly soft wood and needles commonly in clusters of 5, with 1 vascular bundle in cross section. The hard pines (subgenus *Pinus* or *Diploxylon*) have mostly hard wood and needles commonly in clusters of 2 or 3, with 2 vascular bundles in cross section.

F—490470

# LODGEPOLE PINE (*Pinus contorta* Dougl.)

Other common names: Black pine, scrub pine, shore pine, coast pine, tamarack pine.

Lodgepole pine grows from southeastern Alaska and the interior Yukon Territory south to northern Baja California and east to the Black Hills of South Dakota. The northern limit occurs at about 64° N. latitude on the divide between the Klondike and McQueston Rivers; the southern limit at about 31° N. latitude in the northern part of Sierra San Pedro Martir in Baja California.

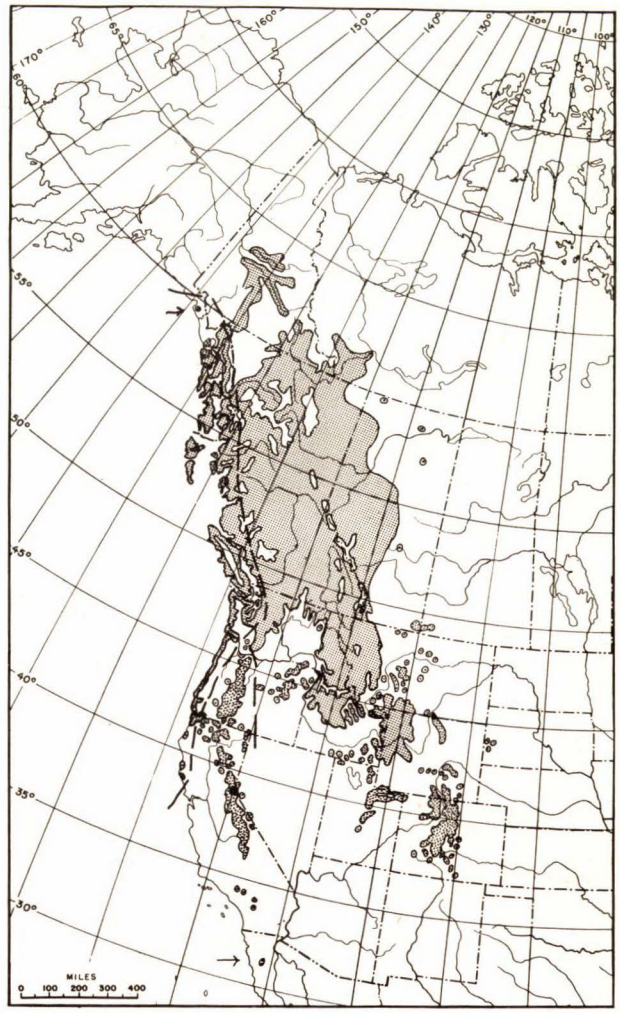
Some taxonomists distinguish two varieties of this pine: *Pinus contorta* var. *contorta*, a coastal form, and *P. contorta* var. *latifolia*, an inland or mountain form. The coastal form is a low, scrubby tree growing along the Pacific coast from southeastern Alaska to northern California, while the inland form is a taller tree of the mountains from the Yukon southeast to Colorado. Recently a detailed study (*17*)[1] of the geographic variation of this pine has shed new light on its taxonomy, and it has been proposed that the species be divided into four subspecies. Under this interpretation the tree of the Cascade and Sierra Nevada mountains is separated as *P. contorta* var. *murrayana* (Grev. & Balf.) Engelm.

Lodgepole pine existed in the Tertiary age in Yellowstone National Park (*32*). A fossil serotinous cone was found from a tree believed to be the immediate ancestor of the lodgepole pine of today and later was named *Pinus premurrayana*.

## HABITAT CONDITIONS

### Climate

In most areas where the interior form of lodgepole pine grows, the summers are fairly dry and precipitation is likely to be deficient for short periods during the growing season. Best development occurs where annual precipitation is 21 inches or more, but extensive stands are found where precipitation is only 18 inches (*46*). Annual snowfall generally varies from 11 to 120 inches, but may reach as much as 250 inches or more and lie on the ground until late spring (*48*). The growing season is generally short (60 to 100 days), and frosts may occur every month in the year. Average July temperatures are generally between 55° and 63° F. and temperature extremes of 100° and −55° occur for short periods (*46*). The climate of the coastal form's range is typically cool and moist with a narrow range of temperatures.

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The range of lodgepole pine, separated into the coastal, Rocky Mountain, and Sierra Nevada groups.

### Soils and Topography

In the interior region good stands are found on soils derived from granite, shale, or sandstone. Also, extensive stands grow on soils from coarse-grained lavas. In the United States, soils derived from limestone or fine-grained igneous rocks generally do not support good stands (*7*). The former are too dry, and the latter break down into clays that are too poorly drained. However, in Alberta, Canada, stands of medium to good productivity

[1] Italic numbers in parentheses refer to Literature Cited, p. 380.

commonly occur on well-drained, calcareous tills having a silty loam or clay loam texture.[2]

In the Cascade Mountains of Oregon and Washington and the Sierra Nevada in California, lodgepole pine is found mainly on wet flats and poorly drained soils. In the Sierra Nevada the incidence of small lodgepole pine stands within ponderosa pine stands is determined by the presence of a clay pan impervious to moisture under the lodgepole (*41*). Similarly, in eastern Oregon, soils with underlying hardpan, which helps retain soil moisture in the root zone, support lodgepole pine to the exclusion of ponderosa pine (*56*). Extremely dwarfed stands of lodgepole pine occur on highly acid hardpan soils in some areas of Mendocino County, Calif. (*49*).

In central Oregon, lodgepole pine grows mainly on level sites having a relatively high water table or on poorly drained soils. However, at elevations above the 5,000- to 6,000-foot zone, it is found on sites that are well or excessively drained. In these areas the pattern of occurrence is believed to be created by past fires.

In the Blue Mountains of northeastern Oregon and southeastern Washington, it is nearly always found on volcanic ash (pumicite) soils or alluvial material overlying residual basaltic soils at elevations between 3,000 and 7,000 feet (*78*). These soils are much deeper than the residual soils of the area and afford the greater moisture supply necessary for aggressive lodgepole pine growth.

Pure stands of the scrubby coastal form are found in peat bogs or muskegs in southeastern Alaska and British Columbia and in the Puget Sound Basin of western Washington. Similar stands occur farther south on dry sandy and gravelly sites near the Pacific Ocean.

Freshly fallen lodgepole pine leaves in one study in the northern Rocky Mountains had the following nutrient content (*23*).

| | *Percent of oven-dry weight* | | |
|---|---|---|---|
| | *Minimum* | *Mean* | *Maximum* |
| Nitrogen | 0. 38 | 0. 59 | 0. 67 |
| Phosphorus | . 04 | . 04 | . 05 |
| Potassium | . 13 | . 20 | . 33 |
| Calcium | . 54 | . 64 | . 73 |

The average phosphorus content of lodgepole pine leaf litter was the lowest of 12 native conifers studied in this region.

The altitudinal range of lodgepole pine extends from sea level up to 11,500 feet. The coastal form is restricted to elevations at near sea level to about 2,000 feet. The inland form occurs from 1,500 feet to 11,500 feet elevation. In the Yukon Territory, at the northern part of its range, lodgepole is found between 1,500 and 3,000 feet elevation; farther south in Montana, east of the Continental Divide, between 14,500 and 9,000 feet; in northern Wyoming between 6,000 and 10,500 feet; and in southern Wyoming and Colorado between 7,000 and 11,500 feet.

Lodgepole pine generally grows in mountainous regions, but may be found under a great variety of topographic conditions. It grows especially well on gentle slopes and in basins, but many good stands are found on rough and rocky terrain (*69*). On steep slopes and ridges it grows on bare gravel (*46*). Northern and eastern aspects are more favorable to the species than western aspects. Southern aspects are least favorable except in sheltered locations.

## Associated Trees and Shrubs

Lodgepole pine is a major timber species in the Canadian Life Zone of both the Cascade-Sierra and Rocky Mountain ranges. The Lodgepole Pine Type (Type 218) is part of the forests of the interior middle elevations and is considered pure when there are no significant amounts (more than 20 percent) of either western white pine or ponderosa pine. However, minor numbers of several species may be present. The coastal form is not recognized as a distinct type.

This pine is represented in 11 other forest cover types of western North America. At high elevations in the mountains it is a minor component of these types: Engelmann Spruce—Subalpine Fir (Type 206), Red Fir (Type 207), and Whitebark Pine (Type 208). At middle elevations in the interior it is a minor component of the following types: Interior Douglas-Fir (Type 210), Larch—Douglas-Fir (Type 212), Ponderosa Pine—Larch—Douglas-Fir (Type 214), Western White Pine (Type 215), Rocky Mountain Juniper (Type 220), and Aspen (Type 217). It is also found in the Western Juniper Type (Type 238), which occurs at low elevations in the interior, and in the Jeffrey Pine Type (Type 247), which occurs at middle elevations in northern California.

In Alberta, Canada, the lodgepole pine community is described in four phytogeographical divisions as follows (*38*):

| *Division name* | *Elevation* |
|---|---|
| Montana | Middle altitudinal zone between prairie and subalpine vegetation |
| Subalpine | 4, 500 feet to timberline |
| High foothills | 4, 000 to 6, 000 feet |
| Low foothills | 2, 500 to 4, 000 feet |

Although dense lodgepole pine forests generally lack minor flora, certain shrubs and occasionally herbs typify the stands if they are not heavily overstocked and where they do not occur in a transition zone between other timber types. The following are plants in the principal localities where

[2] Communication from Canada Department of Northern Affairs and National Resources, Calgary, Alberta, October 15, 1956.

lodgepole pine can be defined as a true cover type:

a. Cascade Range in Washington and Oregon—*Xerophyllum tenax*, *Pachistima myrsinites*, *Vaccinium* spp., *Arctostaphylos nevadensis*, *Amelanchier* spp. (*28*).

b. Sierra Nevada in California—*Prunus emarginata*, *Arctostaphylos nevadensis*.

c. Bitterroot Mountains in Idaho—*Amelanchier* spp., *Prunus emarginata*, *Holodiscus discolor*, *Rosa* spp., *Symphoricarpos* spp. (*24*), *Xerophyllum tenax*, *Vaccinium myrtillus* (*44*).

d. Central Montana—*Vaccinium scoparium*, *Cercocarpus ledifolius* (*36*), *Calamagrostis rubescens* (*46*).

e. Southern Idaho, Utah, and Wyoming—*Calamagrostis rubescens*, *Juniperus communis*, *J. sibirica*, *Pachistima myrsinites*.

f. Central Rocky Mountains in Colorado—*Shepherdia canadensis*, *Vaccinium scoparium*.

In the south central interior of British Columbia the inland form of lodgepole is found on five major and four minor site types (*42*). In descending order of site quality the major site types are: *Cornus*—moss, *Calamagrostis*, *Calamagrostis*—*Vaccinium scoparium*, *Calamagrostis*—*Arctostaphylos*, and *Arctostaphylos*—lichen.

## LIFE HISTORY

The following statements apply mainly to lodgepole pine in the most important part of its range in this country and in Canada; namely, northern Colorado, western and southern Wyoming, western and central Montana, northern Utah, southern Idaho, eastern Oregon, western Alberta, and southern British Columbia.

### Reproduction and Early Growth

*Flowering and fruiting.*—Three-year records at latitude 39° N., longitude 120° W. at 6,000 feet above sea level near Lake Tahoe, Calif., show the earliest collection date for pollen from the inland form to be June 5, the latest date July 8, and the mean date June 22 (*25*). The mean collection date for pollen from the coastal form in a single year's observations at latitude 39° N., longitude 124° W. near Point Arena, Calif., was June 9. These collection dates precede the time of pollen shedding and indicate instead pollen maturing.

Cones from the current year's crop of the inland form mature in August and September; the coastal form, September and October. Most of the viable seed is borne on scales nearest the tip of the cone, except for the first few scales. The extreme basal scales and all undeveloped scales are generally barren. During their development, conelets frequently tend toward one-sidedness, resulting in a flattening or even a concavity of the undeveloped side. Usually the seeds are entirely in the upper half of the cone (*8*).

A recent study (*17*) shows that maximum cone asymmetry is associated with large angles of cone attachment to the branches and with high cone specific gravity. This is especially true of the asymmetrical cones from trees growing in the Rocky Mountains. Cones from trees in the Sierra Nevada, which have a low specific gravity and which are attached to the branches at approximately right angles, have maximum asymmetry.

Several abnormalities in the reproductive system of lodgepole pine were reported from a provenance trial in Scotland (*11*). The replacement of male by female strobili, the occurrence of bisexual strobili, and atypical positioning of cones along shoots were found mainly on inland provenances.

*Seed production and dissemination.*—Cones bearing viable seed are produced at an extremely early age—in open-grown stands by trees from 5 to 10 years old; in more heavily stocked stands by trees from 15 to 20 years old. Seed from trees less than 10 years old have shown a germination percentage as high as that of seed from mature trees.

Lodgepole pine is a prolific seed producer. Good crops are produced at 1- to 3-year intervals with light crops intervening (*8*, *12*, *47*).

The number of fully developed seeds per cone varies widely, from as few as 1 or 2 to as many as 50. In one study an average of 26 seeds per cone was determined on nine National Forests in Colorado and Wyoming (*46*). Another study showed an average of 40 for large lots of cones (*8*). Unpublished results of several small studies made in Idaho and Montana show averages between 20 and 25 seeds per cone.

Seed yields per tree and per acre vary considerably. Averages of 50,000 and 21,000 seed per tree from old and new cones together were found on areas in Idaho and in Colorado, respectively (*16*). An annual yield of 320,000 seed per acre was estimated for an area in central Colorado and 73,000 per acre for an area in southern Wyoming for a 10-year period (*8*).

Geographic differences in the closed-cone habit of lodgepole pine have been recognized. In most coastal populations serotinous cones are uncommon. Notable exceptions occur on the Mendocino white plains in northern California (*49*), and sporadically in areas not in the immediate vicinity of the coastline, mainly in the low mountains of the northwestern corner of California and southwestern corner of Oregon (*17*).

Throughout much of the inland distribution, cones are generally serotinous, but even here many exceptions are found. Whereas in the Rocky Mountain and Intermountain regions the closed-

cone habit is widespread, in the Sierra Nevada cones open at maturity (*17*, *26*). Trees in the Oregon Cascades, the eastern Siskiyou Mountains, and in southern and Baja California also are reported to have nonserotinous cones (*17*). Other areas where cones have been reported to be mainly nonserotinous are the Deschutes Basin in Oregon (*79*) and the Blue Mountains in northeastern Oregon (*57*, *78*).

In stands that have closed cones, individual trees may have both serotinous and nonserotinous cones, or a preponderance of either kind (*19*).

The closed-cone habit has considerable silvicultural significance. Where serotinous cones are abundant, as in the Rocky Mountain region, a large quantity of sound seed is available for release following fire or cutting. One study showed an amount in closed persistent cones equal to about three times the average current crop (*8*). Germinative potential declines only slowly and much of this seed remains viable for a long time. Viable seeds have been extracted from closed cones 75 to 80 years old (*48*), and a few seeds were germinated from 150-year-old cones imbedded in wood (*51*).

Lodgepole pine seeds weigh about 102,000 seed per pound for the inland form and 135,000 per pound for the coastal form. In still air the seeds fall at an average rate of 2.7 feet per second (*65*).

Seed from standing trees are disseminated throughout the year but not at a uniform rate. In a pure, even-aged, overmature stand in Montana only 20 percent of the yearly crop disseminated was released during August and September in 3 out of 4 years. Sixty-two percent was shed during October to June of the following year, and 18 percent during June and July (*13*). In an uncut overmature stand over a 4-year period, sound seeds were released at the rate of 17,000 per acre per year. On the average in each year 80 percent of the seed came down prior to the following growing season. However on the Pringle Falls Experimental Forest in eastern Oregon at an elevation of 4,300 feet, 90 percent of the seedfall occurs before November (*57*).

In the subalpine forest region of Alberta, Canada, during 3 years of study in a 60-year-old stand, maximum annual seedfall occurred over a 4- to 5-week period and climaxed the first week of October; however, small amounts were released continuously throughout the year (*18*).

Wind is not important in dispersal so far as management of the species is concerned except where cones are predominantly nonserotinous (*76*). Seed in quantities suitable for restocking open areas is seldom scattered beyond 200 feet from the parent trees where cones are serotinous (*13*, *48*). Seed from cones attached to the slash and from cones knocked from the slash and scattered over the forest floor is much more important silviculturally. Maximum seed release from this source takes place after the first year of cone exposure (*13*); some further release occurs for as long as 6 or more years (*71*).

Fire is not a requisite for seed release from closed cones in the slash (*9*, *70*). Usually the resin that seals the scales together melts at 113° F. (45° C.) (*16*), allowing the scales to flex and spread apart. This can occur without fire when enough heat reaches the cone surface through radiation, convection, or conduction (*20*). However, fire may hasten the opening of some cones that are not suitably positioned for the resin bond to be softened by solar heat.

*Seedling development.*—Most viable seed germinate in the spring following dispersal, but a small amount may germinate a year later because of occasional embryo dormancy. Fluctuating temperatures between 47° and 78° F. favor germination (*8*).

Best germination occurs in full sunlight and on mineral soil or disturbed duff free of competing vegetation (*9*, *13*, *21*, *46*, *73*, *77*). A residual overstory following a partial cutting generally reduces germination and survival. In one study, reduction of root competition from a residual stand by trenching increased germination and survival (*1*). For this reason a clear-cutting system is most desirable for reproduction of this species. On many areas, however, lodgepole pine has become established in the shade of lightly cut or uncut stands and may persist for many years.

Roots of lodgepole pine seedlings grow slowly (*8*), often forming a taproot. In one study (*29*) taproots were found not to persist beyond the juvenile years. However, more recently it has been shown that the taproot is maintained but may be bent, stunted, atrophied at its extremity, or obscured by other roots in the system (*39*). The lateral roots develop horizontally outward compared to those of ponderosa pine, which grow obliquely downward (*29*), but later the lateral roots may develop sinkers (*39*).

Lodgepole pine frequently regenerates too abundantly, resulting in stagnation at extremely early ages. For example, on a burn in Montana a single milacre quadrat was stocked with 765 10- to 11-year-old trees (*45*). These trees ranged in height from 4 to 25 inches. In other studies on burns in Montana there were as many as 300,000 1-year-old seedlings per acre, and up to 175,000 8-year-old trees per acre, averaging about 2 feet high. In Colorado 10 small sample plots in a 22-year-old stand established after a fire showed an average of 44,000 trees per acre (*46*). The tendency of this species toward overstocking and stagnation is probably the most extreme of any on the North American continent.

On the Deerlodge National Forest, Montana, in typical fully stocked stands on slightly better-than-average sites, 20-year-old dominant trees average 1.9 inches d.b.h. and 12 feet in height.

Seasonal growth of lodgepole pine has been observed on the east slope of the Rocky Mountains in Alberta and the Sierra Nevada in California. In the subalpine forest of Alberta leader growth of saplings for a 4-year period consistently started in early May and continued for 12 weeks (*40*).

An 8-year record made on the west slope of the Sierra Nevada, at about 5,200 feet elevation, showed that lodgepole pine begins height growth earlier than its common tree associates in this locality. For example, 88 percent of the seasonal height growth of lodgepole pine was completed before white fir started height growth. About 60 percent of the seasonal height growth of lodgepole pine was completed at the time of needle emergence from the fascicle sheath, and all of it was completed before needle growth ceased. Lodgepole pine also ceased height growth before any of its tree associates in this region (*27*).

*Vegetative reproduction.*—Lodgepole pine has been grafted successfully on mature ponderosa pine (*52*) and on Scotch pine (*Pinus sylvestris*) (*37*). It does not reproduce naturally by sprouting. Adventitious roots have been developed artificially from 8-year-old lodgepole pines by air-layering, after treatment with 1.2 percent solutions of either indole acetic or indole butyric acid in a talcum powder carrier. The roots developed from the cambium along with the secondary xylem of the current year's growth, and from parenchymatous callus tissues (*82*).

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200-year-old lodgepole pine on the Targhee National Forest, Idaho.

## Sapling Stage to Maturity

*Growth and yield.*—Lodgepole shows remarkable range in stand density and striking reactions to both density and environment (*66*, *72*). For example, in the Rocky Mountains in 100-year-old stands of varying density the maximum yield was of 20,000 board feet per acre with 800 trees; yield fell off rapidly to less than 1,500 board feet when the number of trees increased to 1,800 (*48*). Stagnated stands 70 years old may have as many as 100,000 trees per acre, averaging only 4 feet in height and less than 1 inch in diameter at the ground.

On the average, yields of 12,000 to 15,000 board feet per acre are considered good in old-growth Rocky Mountain lodgepole pine. Yields of 20,000 to 25,000 board feet per acre are exceptional. Generally, yields per acre are lower in Montana than in Colorado.

The lodgepole growing at a low elevation in northeastern Washington and adjacent areas in northern Idaho has a faster growth rate and dies earlier than the lodgepole pine at higher elevations in Montana. These low-elevation stands generally start breaking up at 80 to 100 years.

Lodgepole pine does not prune well naturally and in open-grown stands branches are retained nearly to the ground. In dense stands the clear-boled appearance of the trees is often misleading. Pruning of the bole for 10 to 25 percent of its length is common. However, pruning often does not progress to complete elimination of the basal part of the branches.

Sizes attained at maturity vary greatly. Within the main lodgepole pine region most trees at 140 years are 7 to 13 inches in diameter and 60 to 80 feet tall (*48*). In the Blue Mountains of Oregon at 100 years old, trees average 12 inches in diameter and 70 to 80 feet in height. At 100 years in the Sierra Nevada trees reach average diameters of 15 to 18 inches and average heights of 90 to 100 feet (*33*).

Trees of the coastal form vary greatly in size at given ages; mature trees are from 6 to 20 inches in diameter and from 20 to 40 feet tall. On a small plateau a few miles wide along the coastal plain of Mendocino County, Calif., an extreme condition is found where mature lodgepole pine is little more than a canelike dwarf 2 to 5 feet high. This dwarfed condition is associated with a highly acid hardpan soil (*49*).

The largest tree of this species on record is 19 feet in circumference at 4½ feet above ground and is 106 feet tall (*3*). It is located outside of

the main lodgepole pine region on the Sierra National Forest in California.

The oldest lodgepole pine stand on record was found on the Beaverhead National Forest in Montana (*46*). Its age in 1915 was 450 years. Trees as old as 600 years have been reported (*17*).

In fully stocked, pure, even-aged stands on medium sites in Montana (Deerlodge National Forest) average heights and diameters of the main stand 7 inches d.b.h. and larger are as follows:

| *Age (years)* | *Height (feet)* | *D.b.h. (inches)* |
|---|---|---|
| 40 | 33 | 7.0 |
| 60 | 54 | 7.8 |
| 80 | 61 | 8.4 |
| 100 | 65 | 8.8 |
| 120 | 69 | 9.2 |
| 140 | 71 | 9.6 |
| 180 | 75 | 10.0 |

In stands of this kind the mean annual increment in cubic feet to a 2½-inch top culminates between 70 and 90 years, and in board feet, measured to a 6-inch top, at 130 years (*47*).

Through thinning in stagnating stands on medium sites in western Montana it has been estimated that yields could be raised from 6 thousand board feet per acre in natural stands to 23 thousand board feet per acre at a rotation of 120 years (*81*).

The cubic-foot volume in fully stocked stands on some of the best sites in British Columbia (site index 80 at 80 years) for trees 6 inches and larger in diameter to a 3-inch top is as follows (*15*):

| *Age (years)* | *Volume per acre (cubic feet)* |
|---|---|
| 40 | 1,560 |
| 60 | 4,200 |
| 80 | 6,200 |
| 100 | 7,550 |
| 120 | 8,450 |
| 140 | 9,000 |

*Reaction to competition.*—Lodgepole pine is a shade-intolerant species (*5*). It is more intolerant than any of its main associates except western larch and ponderosa pine, which is about as tolerant. However, despite its intolerance, which is most pronounced at early ages, lodgepole pine can maintain itself in extremely dense stands for as long as 80 to 100 years. Height growth of dominant lodgepole pine trees in natural stands is reduced with increasing numbers of stems per acre (*60*, *66*, *67*).

For good growth lodgepole pine needs more moisture in the soil and air and a lower average temperature than Douglas-fir and ponderosa pine, but probably less moisture and a higher temperature than Engelmann spruce and alpine fir. Under exposed conditions lodgepole pine is at a disadvantage compared to ponderosa pine. It not only has a greater leaf area per unit of weight than ponderosa pine, but in a windy atmosphere its water loss per unit of leaf area is reported to be four times greater (*29*).

Ecologically, lodgepole pine stands may be grouped into two categories: subclimax stands and transitional stands.

1. Subclimax stands: In these stands lodgepole pine is being held indefinitely on the area by either natural factors other than climate or artificial factors. Stands of this kind exist in their present state because of isolation from effective seed supplies of species that have the potential for replacing them. This condition was initially brought about by fire. Both fire and present soil-water relationships play an important part in its maintenance. These virtually stable tree communities are usually pure lodgepole pine, but frequently minor amounts of other species are present. In some places stands of this kind have occupied the site so long that they appear like climax plant communities. Where this occurs they may be true climax stands and probably will be managed as such.

2. Transitional stands: In these stands lodgepole pine is only a temporary occupant of the site, as shown by one or more of the following conditions:

(a) appreciable amounts of advance reproduction of other species
(b) mixed composition of the overstory
(c) pure lodgepole pine of limited extent

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A 60-year-old stand of pure lodgepole pine in Montana.

within stands of climax species or longer lived species such as western larch.

Such lodgepole pine stands are never remote from the seed of species that can replace them.

Several stands have shown good response to heavy thinning at an early age (*4, 46, 55, 63*). Undamaged advance reproduction showed good response to release the fourth year following clear cutting of a pure lodgepole overstory in Oregon (*77*). Other stands, however, have shown no release when thinned at ages as young as 14 years.[3] Evidence indicates that once stagnation has set in it may be difficult to overcome. Thinnings at an age as early as 7 years might need to be made if immediate release is expected (*61*).

At older ages, growth response to release is correlated strongly with crown size and vigor and the amount of release given (*75*). In numerous partial cuttings in Canada net volume growth rate was poor and there was no perceptible increase in diameter growth rate on trees in the residual stand (*14*).

In Colorado diameter growth acceleration was greatest in heavy thinnings; cubic volume and basal area growth was greatest on light thinnings (*2*). In central Oregon height growth as well as diameter growth were positively correlated with amount of release in a 55-year-old stand (*6*).

Thinning in strips brought about diameter growth response in Montana of about the same magnitude as selective thinning did in Oregon and Colorado (*74*).

*Principal enemies.*—The most serious insect enemy of lodgepole pine is the mountain pine beetle (*Dendroctonus monticolae*), which has caused extensive losses in both the United States and Canada. Occasional epidemics have wiped out thousands of acres of trees irrespective of their health or vigor. Trees from 4 inches in diameter up to the largest size have been attacked. The beetles enter mainly along the bole from a few feet above ground up to the middle branches but may also attack the larger limbs and the entire main stem, excepting the extreme top.

The lodgepole pine beetle (*Dendroctonus murrayanae*), a much less aggressive insect than the mountain pine beetle, attacks old or weakened trees at the base. Because it may develop in large numbers in freshly cut stumps, it may become troublesome in old growth along the edges of improvement cuttings or other types of partial cuttings.

In young stands the lodgepole terminal weevil (*Pissodes terminalis*) at times causes great damage by attacking the terminal shoot, producing distorted or forked trees. It is particularly destructive in young open-grown stands in California.

The principal defoliating insects are the lodgepole needle miner (*Recurvaria milleri*), the lodgepole sawfly (*Neodiprion burkei*), and the spruce budworm (*Choristoneura fumiferana*). Complete defoliation by the needle miner causes mortality. Forty percent defoliation causes significant reductions in both terminal and lateral growth. There is evidence that lodgepole pine can withstand defoliation up to 30 percent without radial growth reduction (*68*).

Dwarfmistletoe (*Arceuthobium americanum*) is widespread throughout the lodgepole pine type and causes a large but as yet undetermined amount of growth loss (*80*). In Colorado and Wyoming on three National Forests surveyed, virgin stands free of dwarfmistletoe had nearly 1.5 times the volume of infected stands. Recent mortality rates in infected virgin stands were 1.3 times that in mistletoe-free stands (*34*).

The parasite develops most rapidly in vigorous hosts (*30*). Infections develop nearly twice as fast in dominants as in suppressed trees. Spread of infection down the stem is about ⅓ faster than up the stem (*35*).

In general, damage from dwarfmistletoe can be grouped into four categories (*43*) : increased mortality, growth reduction, quality reduction, and seed reduction.

Reproduction that develops beneath an infected overstory is most likely to become infected. Dwarfmistletoe appears to increase its vigor and "broom out" when partial cutting is practiced. Because of its prevalence in the lodgepole pine type, silvicultural management of the species must be positively geared to its control.

Three stem rusts and several heart rot and root rot fungi cause mortality and cull in lodgepole pine. The comandra rust (*Cronartium comandrae*) is the most important rust because it causes widespread mortality in trees of all ages. Western gall rust (*Peridermium harknessii*), which occurs throughout the tree's range, causes considerable mortality to seedlings and causes bole deformity and breakage in older trees. *P. stalactiforme* causes some mortality, but is considered important principally because bole infections ruin living trees for either lumber or pulpwood (*46, 50, 58*).

The heart rot fungi, *Fomes pini* and *Stereum pini*, probably cause most cull in lumber trees, but several other stem, butt, and root rot fungi are important decay organisms (*58*).

Tumors, apparently of pathogenic origin, occur on lodgepole pine stems in epidemic proportions in northern Wyoming and in scattered stands in Colorado and Montana. Bole deformities caused by tumors make tree trunks unsuitable for normal uses (*62*).

A condition similar to that of pole blight in western white pine has been reported in several

[3] Written communication from D. I. Crossley, Alberta, Canada, dated September 24, 1956.

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parts of British Columbia, Canada (*59*). Symptoms are crown deterioration, bark lesions, and reduced radial increment. Its cause is as yet undetermined.

Because of its relatively thin bark, the tree is more susceptible to fire than Douglas-fir and any of the pines with which it grows, but is less susceptible than Engelmann spruce and subalpine fir (*46*). Lodgepole pine trees killed by fire or insects may remain standing for 20 or more years. Standing dead trees decay slowly but often check so badly that merchantable lumber cannot be sawed from them (*10*).

Because of its root habit lodgepole pine generally is considered suspectible to windfall, although, as with other species, its windfirmness varies with topography, soil conditions, and stand density. In many areas it is relatively windfirm, except where it develops shallow roots because of impermeable layers and excessively shallow, stony soils.

Chinook winds occasionally cause red belt injury. Although mortality from this cause is rare, partial defoliation of trees is not uncommon (*36*).

Snowbreak and snowthrow occur in dense natural thickets where root competition is keen. Slender whippy trees with short, narrow crowns are particularly susceptible. Following clear cutting in Oregon, snow damage is common in stems less than 6 inches in diameter (*77*). Small leave trees are frequently bent to the ground in deep snow country when overcrowded stands are opened by thinning.

In a thinning study made in Utah, 16 years after thinning in a 28-year-old stand, 44 percent of the leave trees over 4 inches d.b.h. were damaged by porcupines (*22*).

## RACES AND HYBRIDS

Seed planted in Finland from nine Canadian sources produced trees that varied in form, growth rate, and disease resistance. In Sweden, better trees were produced from seed from an Alberta, Canada, provenance than those from Colorado or Montana sources. After storage at a low temperature, seed from warmer climates germinate more slowly than those from colder climates. Seed from higher elevations germinate better at low temperatures (66° F.) than seed from lower elevations. Correspondingly, seed from lower elevations germinate better at higher temperatures than high-elevation seed (*31*).

The most recent study of morphological and physiological variation in lodgepole pine (*17*) provides additional evidence of regional differentiation within the species. Separate taxonomic recognition of four groups of lodgepole pine are proposed as follows:

Coastal group: *Pinus contorta* Douglas ex Loudon ssp. *contorta*

Mendocino white plains group: *Pinus contorta* ssp. *bolanderi* (Parl.) stat. nov.

Sierra Nevada group: *Pinus contorta* ssp. *murrayana* (Balf.) stat. nov.

Rocky Mountain group: *Pinus contorta* ssp. *latifolia* (Engelmann ex Watson) stat. nov.

Within some parts of the species distribution certain character gradience, or clines, are also expressed. Most of the morphological characters studied vary somewhat regularly with elevation but not with latitude.

Natural hybrids of lodgepole pine with jack pine (*Pinus banksiana*) are found in Alberta, Canada, where the two ranges overlap (*54*). Crosses between these two species can also be made by controlled pollination (*64*).

Turpentine from the $F_1$ generation of the artificial crosses has a greater amount of the bicyclic jack pine terpenes than the monocyclic lodgepole pine terpene, phellandrene. The ratio is about 3 to 1. Morphologically, more trees in the natural hybrid swarms look like lodgepole pine than jack pine. However, chemical analysis of the terpenes of trees in this area show that they tend more toward a predominance of jack pine pinenes (*53*).

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*Revised from "Silvics of Lodgepole Pine," by David Tackle. U.S. Forest Serv. Intermountain Forest and Range Expt. Sta. Misc. Pub. 19, 24 pp. 1959.*

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